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COMMERCIAL AND RECREATIONAL FISHERIES FOR SPANISH MACKEREL, *Scomberomorus maculatus*

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ABSTRACT Commercial landing data are summarized and fishing gears discussed for Spanish mackerel, *Scomberomorus maculatus*, in the United States from 1880 to 1976. The commercial fishery began along the middle Atlantic and Chesapeake Bay areas before 1850, and by 1880 about 86% of the total U.S. catch of 1.9 million pounds was landed in the Chesapeake Bay area. Before 1920 the fishery had become centralized in Florida. Since 1950, over 92% of the total U.S. catch each year was landed in Florida. Spanish mackerel landings in the United States ranged between 5.0 and 12.1 million pounds from 1950 through 1975, increasing from about 11.3 million pounds in 1975 to about 18.0 million pounds in 1976. Dockside values of the landings fluctuated between $0.5 and $0.9 million from 1950 through 1965, generally increased from 1966 through 1975, and abruptly increased to $3.2 million in 1976. Prices paid per pound increased from $0.13 in 1972 to $0.18 in 1976.

The Spanish mackerel commercial fishery began as a troll fishery, went through a period where gill nets and pound nets caught most of the fish, and later became mostly dependent on gill nets. From 1950 to 1974 the average percentages of the total landings taken by each gear were: gill nets, 87; haul seines, 6; lines, 5; trammel nets, 1; and other, 1.

Recreational-catch statistics representing broad geographic areas of the United States are limited to data from the angling surveys conducted in 1960, 1965, and 1970. Based on these surveys, the most productive fishing areas for Spanish mackerel were along the south Atlantic and east Gulf of Mexico; most were caught in the ocean as opposed to bays and sounds; mainly small boats were used to capture mackerel, but mackerel were also caught from charter boats, piers, jetties, bridges, and beaches. In the 1970 survey, an estimated 536,000 recreational fishermen caught about 15 million Spanish mackerel. The value of the recreational fishery for Spanish mackerel in 1970 was estimated between $15 and $46 million. Valid comparisons of total catch or catch per-unit-of-effort between survey periods could not be made; the reasons are discussed.

Fishing effort and age composition data are needed to evaluate the status of the stocks and, in addition, socio-economic data are needed to determine optimum yields.

INTRODUCTION

The Spanish mackerel, *Scomberomorus maculatus*, a member of the family Scombridae, is closely related to the king mackerel, *S. cavalla*, the cero, *S. regalis*, and the recently-described Brazilian Spanish mackerel, *S. brasiliensis*. All except the latter are widely distributed throughout the western U.S. Atlantic with centers of abundance in Florida. The Spanish mackerel supports important commercial and recreational fisheries in the U.S. south Atlantic and Gulf of Mexico (Figure 1). It is prized as a food item and as a highly desirable recreational fish. The direct economic value of the Spanish mackerel resource is considerable. In 1976, about 18 million pounds valued at about $3.2 million were landed by commercial fishermen in the United States. In 1970, it was estimated that about 23 million pounds were landed by recreational fishermen in the mid-Atlantic, south Atlantic, and Gulf of Mexico. In this paper we review historical landings and the development of the fishing gear used in the Spanish mackerel commercial fishery, describe the present-day commercial and recreational Spanish mackerel fisheries, and discuss factors that are required to evaluate the status of the stocks and fisheries.

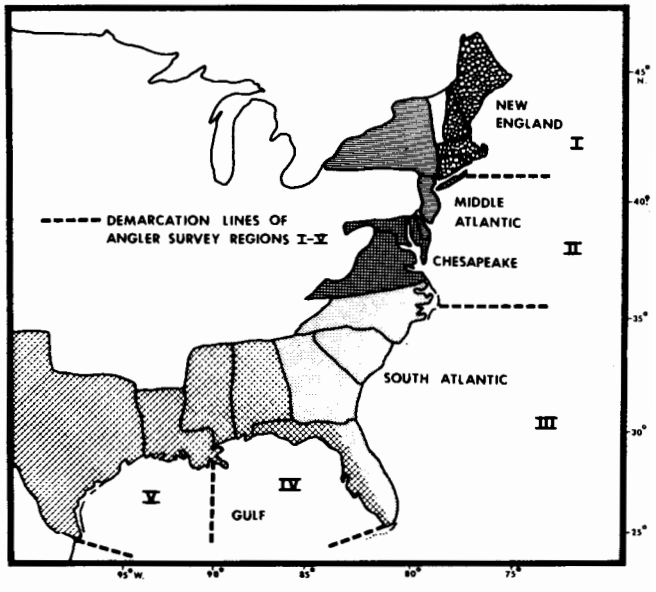

Figure 1. Geographic areas (commercial) and regions (recreational) used for reporting fishery statistics along the Atlantic coast of the United States (Fishery Statistics of the United States 1977 and Deuel 1973).

COMMERCIAL FISHERY LANDINGS

The commercial fishery for Spanish mackerel in the

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United States began before 1850 along the Long Island and New Jersey coasts and was well established in the mid-Atlantic and Chesapeake Bay areas by the late 1870s (Earll 1887). Catch statistics for this fishery in 1880 showed that the Chesapeake Bay area produced about 86% of the total catch of about 1.9 million pounds (Table 1). In 1880, less than 2% of this catch was recorded from the south Atlantic and Gulf of Mexico. Spanish mackerel (or probably a closely-related species – see Collette, Russo, and Zavala-Camin 1978) were first reported in the landings on the Pacific coast in 1904 when 615,000 pounds were landed. The Pacific coast fishery declined since its beginning as indicated by the following landing statistics: 1908, 349,000 pounds; 1915, 397,000 pounds; 1918 through 1951, less than 44,000 pounds landed each year; 1952 through 1974, none reported. Landing statistics for Spanish and king mackerels in the United States were summarized through 1967 by Lyles (1969). Landings from 1967 through 1976 are summarized in Appendix Tables 1 through 4 (data from Fishery Statistics of the United States 1971–77 and Fisheries of the United States 1967–77).

TABLE 1.

Pounds of Spanish mackerel landed by area and state in 1880 (Earll 1887).

Area and state	Pounds	Percent of total
New England		
Maine	0	
New Hampshire	0	
Massachusetts	60	
Rhode Island	2,000	
Connecticut	1,200	
Subtotal	3,260	0.17
Middle Atlantic		
New York	25,000	
New Jersey	200,000	
Delaware	0	
Subtotal	225,000	11.92
Chesapeake		
Maryland	18,000	
Virginia	1,609,663	
Subtotal	1,627,663	86.24
South Atlantic		
North Carolina	10,000	
South Carolina	1,000	
Georgia	0	
East Florida	500	
Subtotal	11,500	0.61
Gulf of Mexico		
West Florida	*	
Alabama	*	
Mississippi	*	
Louisiana	*	
Texas	*	
Subtotal	20,000	1.06
TOTAL	1,887,423	100.00

*Data not available

The areas of major production changed during the 1880s, and by 1897 about 64% of the Spanish mackerel produced by commercial fishermen in the United States was landed in the south Atlantic and gulf states (Figure 2). This trend in greater proportionate landings of Spanish mackerel in the south continued, and in 1945 over 97% of the total production on the Atlantic coast occurred in the south Atlantic and gulf areas. Florida landings accounted for over 92% of the Spanish mackerel produced in the United States each year from 1950 through 1976 (Table 2).

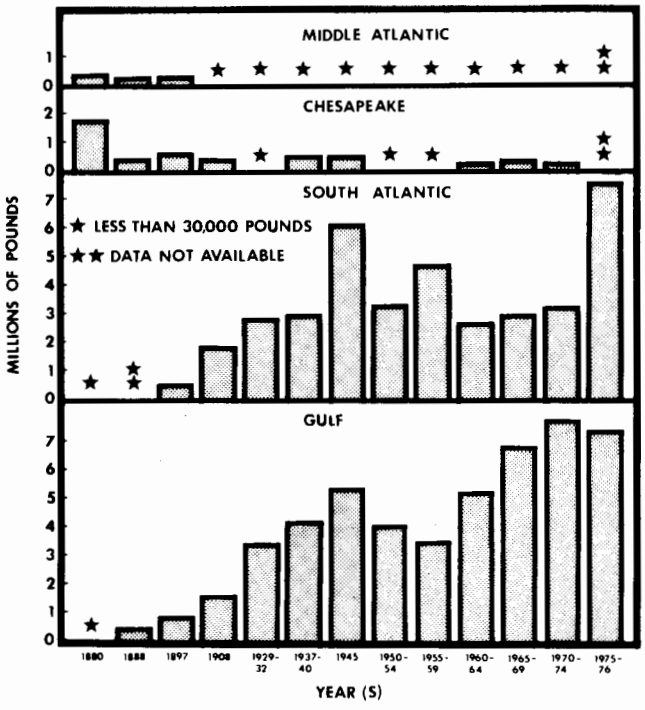

Figure 2. Total or mean total commercial landings of Spanish mackerel from the Atlantic coast of the United States by area and year(s) that comparative data were available, 1880–1976 (Lyles 1969 and Appendix Table 1).

TABLE 2.

Mean annual landings of Spanish mackerel by state in the south Atlantic and gulf areas, 1950–1976 (Lyles 1969 and Appendix Tables 3 and 4).

State	Subtotal	Annual mean	Percent of total
	Thousands of pounds		
North Carolina	3,535	130.9	1.4
South Carolina	186	6.9	9.1
Georgia	27	1.0	0.0
Florida – East	91,967	3,406.2	37.7
Florida – West	143,745	5,323.9	58.9
Alabama	1,900	70.4	0.8
Mississippi	1,691	62.6	0.7
Louisiana	914	33.8	0.4
Texas	19	0.7	0.0
TOTAL	243,984	*	100.0

*Not computed

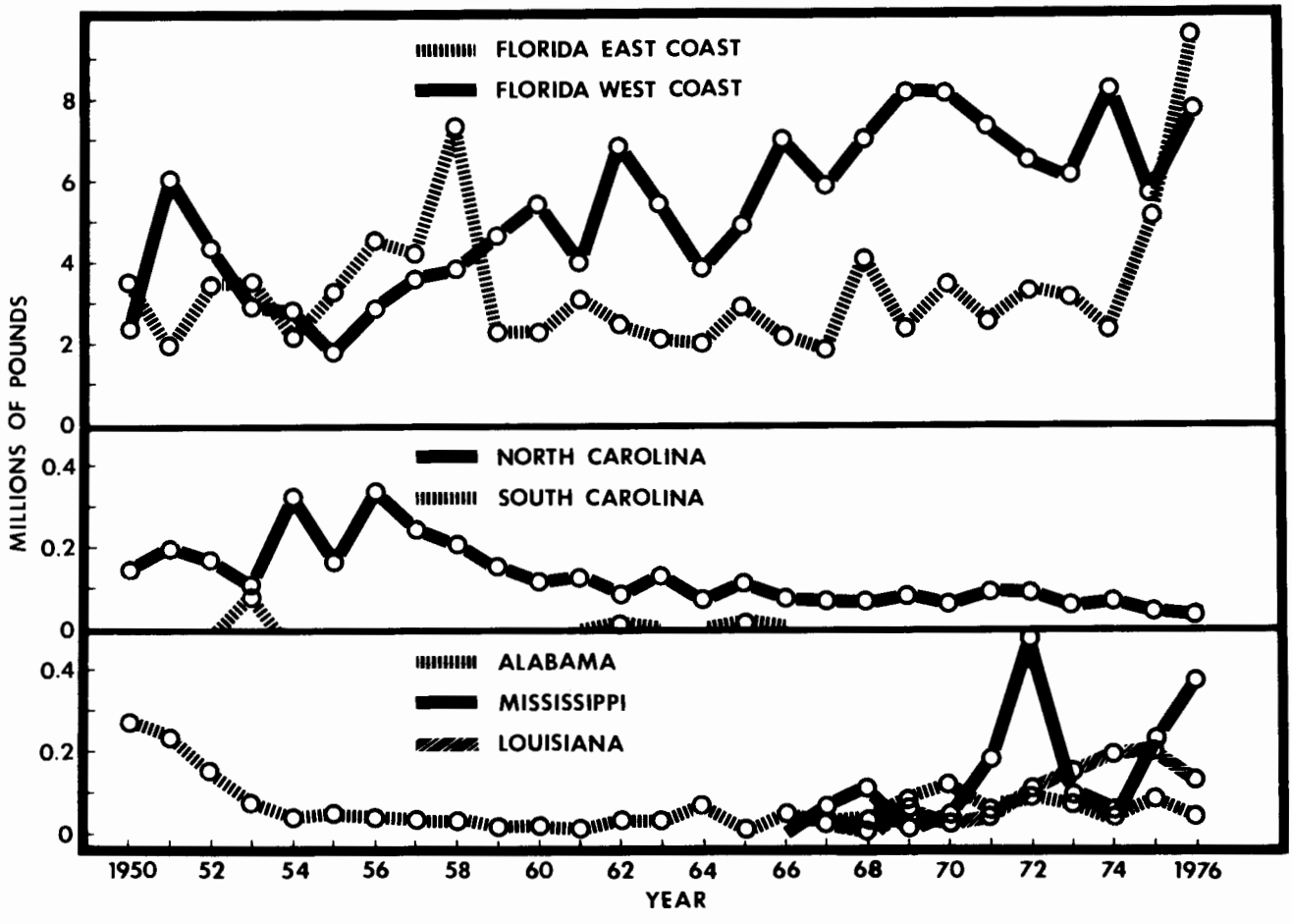

Figure 3. Total annual commercial landings of Spanish mackerel by state or coast of Florida in the south Atlantic and gulf areas for those states and years that 10,000 pounds or greater were landed, 1950–1976 (Lyles 1969 and Appendix Tables 3 and 4).

Trends in the annual landings of Spanish mackerel in the south Atlantic and Gulf of Mexico during the last 27 years are shown in Figure 3 for all states except Georgia and Texas where landings averaged less than 2,000 pounds per year (Table 2). Landings in North Carolina were distinctly higher during the 1950s than during the 1960s and 1970s. On both coasts of Florida, landings of Spanish mackerel fluctuated considerably during the 1950s. From 1960 through 1974, landings on the west coast remained higher, and increased at a higher rate than on the east coast. During 1975 and 1976, an abrupt change occurred; landings on the east coast increased from 2.3 million pounds in 1974 to 9.5 million pounds in 1976, and for the first time in 18 years were higher than on the west coast. Landings in Alabama were higher in 1950–51 than before. Landings of above 50,000 pounds in Mississippi occurred for the first time in 1967 and were highest in 1972 and 1976. Landings in Louisiana have been generally increasing since 1968.

Over 86% of the Spanish mackerel landings in Florida occurred in eight counties during the period 1966–76 (Table 3 and Figure 4). Three of the counties – St. Lucie, Martin, and Palm Beach – are located in the Fort Pierce area along the Atlantic coast and accounted for about 30% of the Florida landings. Monroe, Collier, and Lee counties – located on the southwest side of Florida and including the Keys – accounted for about 49% of the Florida catch. Gulf and Bay counties, located in the northwest area of Florida, accounted for about 8% of the total catch. No other coastal county contributed more than 2% of the total landings.

Trends in the annual landings of Spanish mackerel in the Fort Pierce, southwest, and northwest areas of Florida from 1966 through 1976 are shown in Figure 4. Annual landings in the Fort Pierce area ranged from about 1.5 to 4.1 million pounds from 1966 to 1974 and then increased about 5-fold from 1974 to 1976. Landings in the southwest area fluctuated greatly between 1966 and 1976 from a low of about 3 million pounds to a high of about 7.2 million pounds. Landings in the northwest area gradually increased from 1966 to 1972 and then declined annually through 1976.

Seasonality of Spanish mackerel landings varies in relation to geographic area. In Florida, most of the landings in the Fort Pierce and southwest areas occur between October and May, whereas in the northwest area most of the landings occur during the spring (April – May) and

fall (September – October) (Figure 5).

The dockside values of Spanish mackerel landed by commercial fishermen in the Gulf and south Atlantic areas exceeded $1 million only in one year (1945 – $1.4 million) before 1950 (Lyles 1969). Landing values remained between $0.5 and $1 million per year from 1950 through 1965, generally increased from 1966 through 1975, and abruptly increased during 1976 (Figure 6). The large increase in value in 1976 resulted from increased prices coupled with increased landings (Figure 7). Prices paid per pound fluctuated between $0.08 and $0.12 from 1950 through 1972 and then increased to a high of $0.18 in 1976. It appears that the higher level of prices that began in 1973 was caused by increased demand and that commercial fishermen had geared up by 1976 to fill this demand. An economic analysis of production and marketing trends for Spanish and king mackerels during recent years was conducted by Prochaska and Cato (1977).

TABLE 3.

Total landings of Spanish mackerel by county in Florida, 1966–1976 (Fisheries of the United States, 1976–1977).

County or countries	Thousands of pounds	Percent of total
Nassau	17	0.01
Duval	99	0.08
Putnam	0	0.00
St. Johns	30	0.03
Volusia	518	0.44
Brevard	2,369	1.99
Indian River	671	0.57
St. Lucie	11,763	9.92
Martin	12,607	10.64
Palm Beach	11,191	9.44
Broward	1	0.00
Dade	1,290	1.09
Monroe	42,577	35.92
Collier	9,612	8.11
Lee	6,114	5.16
Charlotte	884	0.75
Sarasota	1,375	1.16
Manatee	2,010	1.70
Hillsborough	29	0.02
Pinellas	1,813	1.53
Pasco, Hernando, and Citrus	108	0.09
Levy	98	0.08
Dixie and Taylor	100	0.08
Wakulla	80	0.07
Franklin	238	0.20
Gulf	4,078	3.44
Bay	5,114	4.31
Walton	14	0.01
Okaloosa	1,649	1.39
Santa Rosa	9	0.01
Escambia	2,070	1.75

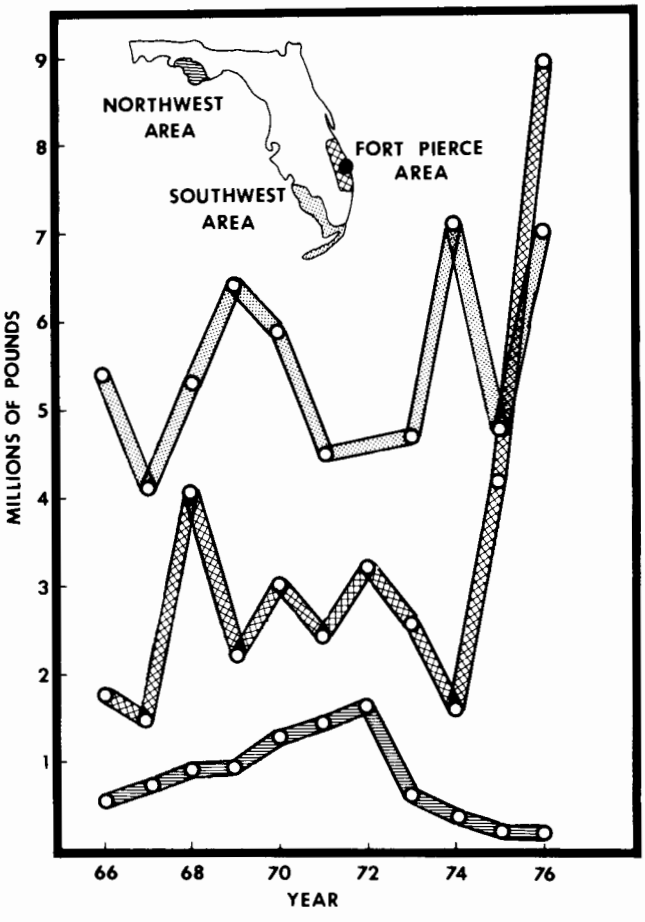

Figure 4. Total annual commercial landings of Spanish mackerel for the most productive geographic areas in Florida, 1966–76 (Florida landings, 1967–1977).

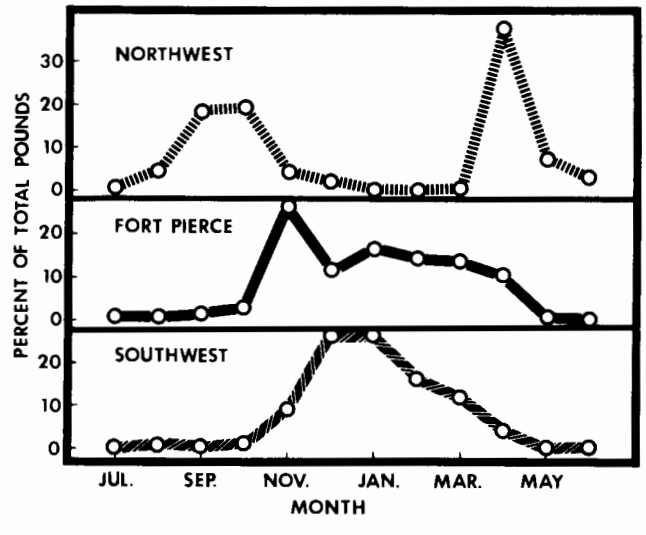

Figure 5. Seasonality of landings in the commercial Spanish mackerel fishery in three areas (Figure 4) of Florida (Florida landings monthly 1968–1971).

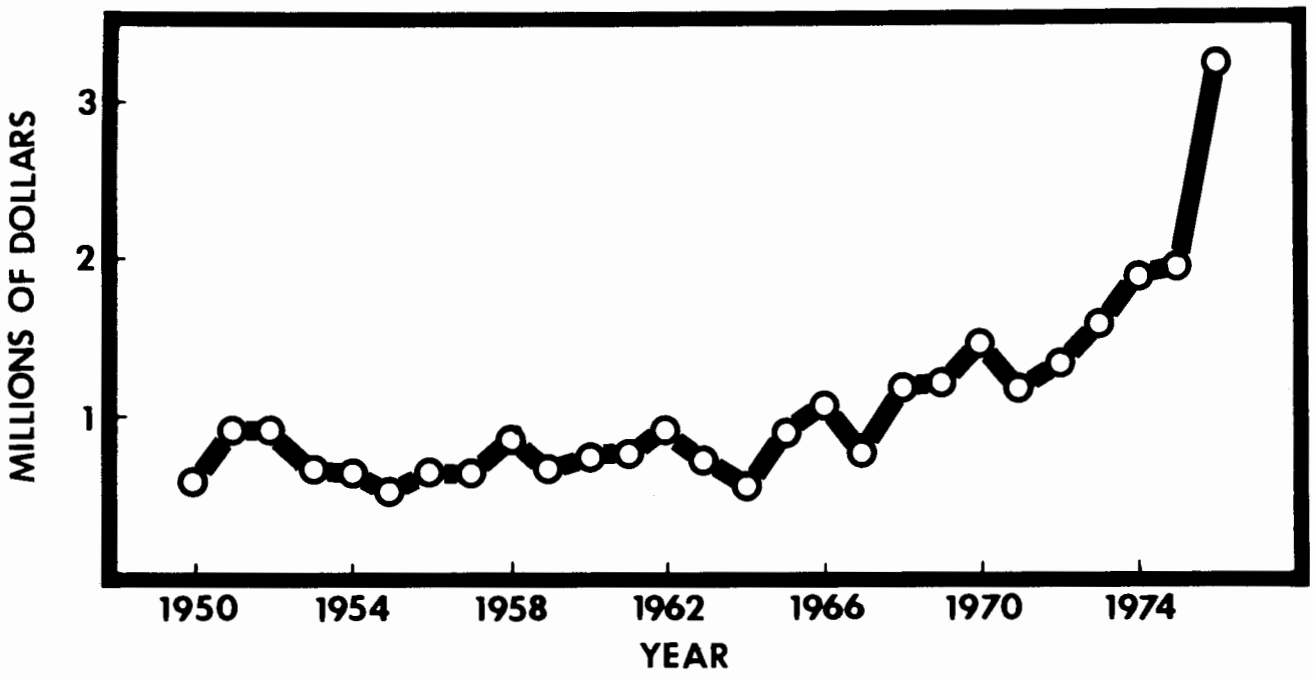

Figure 6. Dockside values of Spanish mackerel landed by commercial fishermen in the south Atlantic and Gulf areas, 1950–1976 (Lyles 1969 and Appendix Table 1).

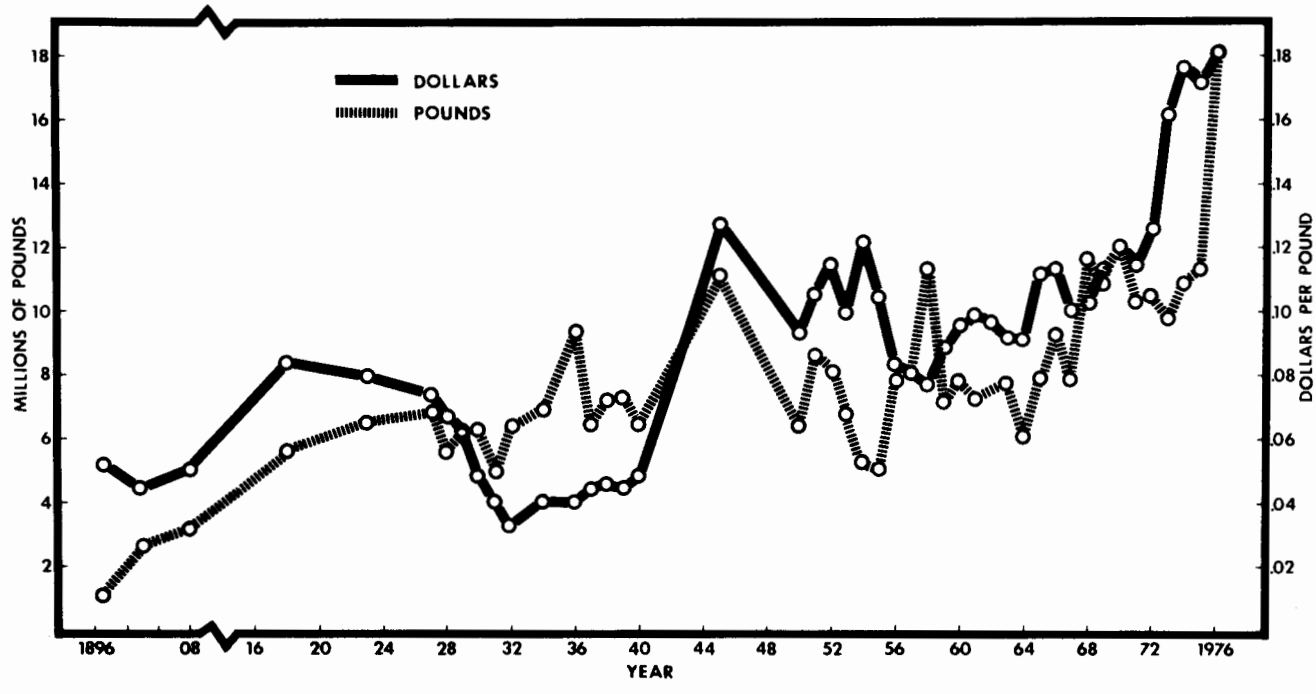

Figure 7. Total pounds and mean dockside values per pound of Spanish mackerel landed by commercial fishermen in the south Atlantic and Gulf areas, 1896–1976 (Lyles 1969 and Appendix Table 1).

COMMERCIAL FISHING GEAR AND TECHNOLOGY

During the nineteenth century three types of gear (troll lines, gill nets, and pound nets) were used in the Spanish mackerel commercial fishery. Troll lines were used first and introduced into the Long Island and New Jersey areas during the early 1800s. For some time, trolling was the most important fishing method (Earll 1887). The trolling lures, or "squids," varied greatly. Some were made of bright metal to resemble fish and others were made of strips of colored cloth to resemble squid. The lures had one to three hooks and were attached to lines several fathoms long. Four or five of these lines were towed behind a sailing boat at two to four miles per hour.

Gill nets were first used for capturing Spanish mackerel in 1866 in Sandy Hook, New Jersey, but were inefficient until about 1872 when it was discovered that the mackerel would gill more readily in nets set to present sharp angles (Earll 1883). Gill nets were then introduced into Chesapeake Bay and quickly gained acceptance. The gill nets were 150 to 200 yards long, 100 meshes deep, and had stretched-mesh sizes of 3–1/2 to 4 inches. The webbing was of tarred cotton twine. The nets were fished single or in "gangs" (two or more nets tied together) in two ways. In the first method, the fishermen would stake or anchor a pair of nets (single or in gangs) so that the longer net of the pair served mostly to lead the fish into the shorter net. This shorter net, located at one end of the lead net, created walls of webbing at various angles to the lead net. These nets were first fished from daylight to early afternoon, but it was later learned that the nets caught more fish from mid-afternoon until midnight. The other method involved encircling the mackerel schools and frightening the fish into the meshes by splashing with oars inside the circle. This method was efficient only at night.

Pound nets were first introduced into the Sandy Hook region about 1855, in the inshore areas, but the nets were relatively unsuccessful in capturing Spanish mackerel until about 1873 when a large pound net was placed along the ocean shore; then their importance in the Spanish mackerel fishery was established (Earll 1887). By 1880, pound nets were being used throughout the middle Atlantic and Chesapeake Bay states and accounted for most of the Spanish mackerel landings.

By 1920, the center of the Spanish mackerel fishery had shifted from Chesapeake Bay to south Florida. Although purse seines made occasional large catches and trolling lines contributed a small amount to the total catch, the gill net had become the principal capture gear (Schroeder 1924). The typical gill net was 7 yards deep, 150 to 175 yards long, had stretched-meshes of 3–3/8 to 3–5/8 inches, and the webbing was 6-thread tarred cotton twine. Often the nets were joined to form one that was 500 to 1,800 yards long. The boats in the fishery were 30 to 50 feet long, gasoline-powered, and carried a large searchlight. Schools of mackerel were found at night and rapidly surrounded with the net. Lanterns were mounted along the floatline to indicate the location of the net. After closing the net, dories encircled the floatline, and the fishermen splashed water to frighten the fish into the net. Because the bottom of the net was open, the fish could have easily escaped by sounding, but apparently they remained at the surface and either gilled themselves or jumped the corkline (Schroeder 1924). Catches by the gill-net boats were generally picked up by a run boat and delivered to the dealer, thereby enabling the net boats to remain on the fishing grounds.

Gill nets have remained the dominant gear in the commercial Spanish mackerel fishery and during the past 25 years have accounted for over 83% of the total catch during each 5-year period in the South Atlantic and Gulf of Mexico (Table 4 and Figure 8). The runaround or strike gill net is much more important than are the drift, anchor, set, or stake gill nets in this fishery. Haul seines have been second in importance over this period, lines (hand and troll) have been third, followed by trammel nets, otter trawls, pound nets, and purse seines. Percents of the total catch during each time interval (Figure 8) have remained about the same between time periods with gill nets, have increased with time with haul seines, and have generally decreased with time with lines and trammel nets.

The Spanish mackerel gill-net fishery in Florida was categorized by Austin, Browder, Brugger, and Davis (1978) into (1) shallow water, and (2) deep water. In the shallow-water fishery, many of the boats were 30 to 40 feet long, cost about $25,000, were equipped with power rollers and strong engines, and were fished mostly along the Florida Keys and southwest coast. Spanish mackerel were also caught from smaller boats (19 to 25 feet long) in the above areas and in the Fort Pierce and northwest Florida areas. The smaller boats were used to catch several species (e.g., mackerel; mullet *Mugil cephalus*; and bluefish *Pomatomus saltatrix*) depending on availability and value. In the deep-water fishery, the boats were 42 to 63 feet long and cost from $40,000 to $160,000 and were sometimes used to catch king mackerel. Austin et al. (1978) estimated that about 250 shallow-water and 67 deep-water vessels were involved in the Spanish mackerel fishery in Florida in 1977.

Nets used in the shallow-water fishery are worth on the average about $1,500, are made of monofilament webbing, and are variable in length, depth, flotation, and mesh size depending on the intended use (Austin et al. 1978). Strike or runaround nets are about 800 yards long and have stretched-mesh sizes of about 3–5/8 inches. The nets are set around mackerel schools, and the fish are excited to charge the net. Drift nets are up to 1,500 yards long, have stretched-mesh sizes between 3–7/8 and 4–1/4 inches, and often have panels with different mesh sizes for catching other species such as pompano *Trachinotus carolinus*. These nets are set perpendicular to the expected path of the fish and to the tide. Both strike and drift nets are about seven yards deep, have sufficient flotation to maintain the float

TABLE 4.

Mean total landings of Spanish mackerel in the south Atlantic and Gulf areas by gear type and time period, 1950–1974 (Fishery Statistics of the United States, 1953–1977).

Gear type	Time period									
	1950–1954		1955–1959		1960–1964		1965–1969		1970–1974	
	1,000 lbs	Percent	1,000 lbs	Percent	1,000 lbs	Percent	1,000 lbs	Percent	1,000 lbs	Percent
Gill nets										
Runaround	6,176	87.9	6,321	80.2	6,480	84.3	8,167	85.0	8,727	81.3
Drift, other	68	1.0	565	7.2	378	4.9	96	1.0	41	0.4
Anchor, set, or stake	18	0.3	3	0.0	4	0.1	6	0.1	170	1.6
Haul seines	157	2.2	214	2.7	342	4.4	728	7.6	1,079	10.1
Lines										
Troll	194	2.8	416	5.3	221	2.9	205	2.1	237	2.2
Hand	208	3.0	186	2.4	188	2.4	176	1.8	211	2.0
Trammel nets	136	1.9	174	2.2	64	0.8	103	1.1	148	1.4
Otter trawls	4	0.1	*	*	1	0.0	34	0.3	114	1.1
Pound nets	65	0.9	*	*	9	0.1	9	0.1	4	0.0
Purse seines	*	*	*	*	*	*	79	0.8	*	*

*None landed

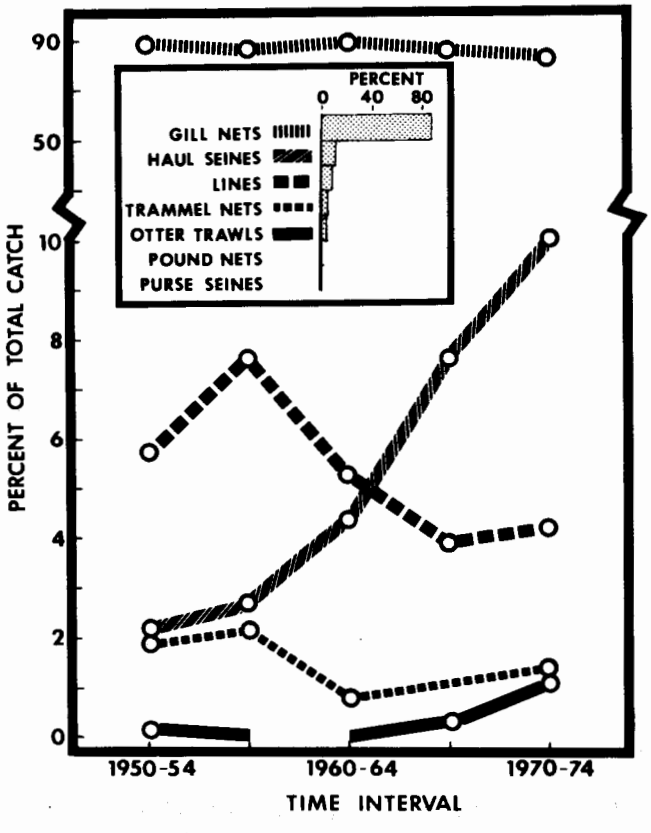

Figure 8. Percents of the total landings of Spanish mackerel in the south Atlantic and Gulf areas in relation to capture gear and time period (Fishery Statistics of the United States, 1953–1977).

line at the surface, and are usually fished in water depths of 8 to 10 feet. Stab nets are up to 1,500 yards long, about 3 yards deep, and usually have stretched-mesh sizes of 4–1/4 inches. They have fewer floats and more lead than strike or drift nets and sink beneath the surface. The nets are set with the tide rather than across it.

Gill nets used for deep-water fishing are strike nets about 600 yards long and up to 30 yards deep and can be fished in water depths of 60 feet. The deep-water nets have webbing made of monofilament about 7 yards deep in the middle of the net and are bounded above and below by multifilament nylon webbing. Mesh sizes are about 3–1/2 inches. The nets are set as in the shallow-water fishery, except that the larger boats use spotter planes to locate fish and direct the setting of the nets. The deeper nets came into use about 1973.

Data on the relation between the mesh sizes of gill nets and the sizes of captured Spanish mackerel were reported by Klima (1959), Powell (1975), and Trent and Pristas (1977); the studies, with the exception of Powell's, clearly showed that the mean or modal lengths of Spanish mackerel increased with an increase in mesh size (Table 5). Although a direct relation exists between the mesh size and the mean size of captured mackerel, this relation is not particularly useful in determining, by the selection of mesh sizes, the sizes of Spanish mackerel that will be caught or protected from being caught (Figure 9). The size ranges of mackerel that are caught by different mesh sizes overlap greatly. The reasons for this overlap are that the girth of a Spanish mackerel

TABLE 5.

Mean or modal lengths of Spanish mackerel caught in gill nets in relation to the mesh size.

Stretched-mesh size (inches)	Mode		Mean
	Klima (1959)	Powell (1975)*	Trent and Pristas (1977)
	(Fork length in centimeters)		
2.5	†	†	33
2.75	†	†	34
3.0	†	†	36
3.13	38	45	†
3.25	†	45	38
3.37	†	45	†
3.5	43	45	40
3.75	†	†	42
4.0	†	†	44
4.25	†	†	46
4.5	†	†	47
4.75	†	†	45
5.0	†	†	49

*Reported in standard length and converted to fork length using the equation by Powell (1975).
†No data.

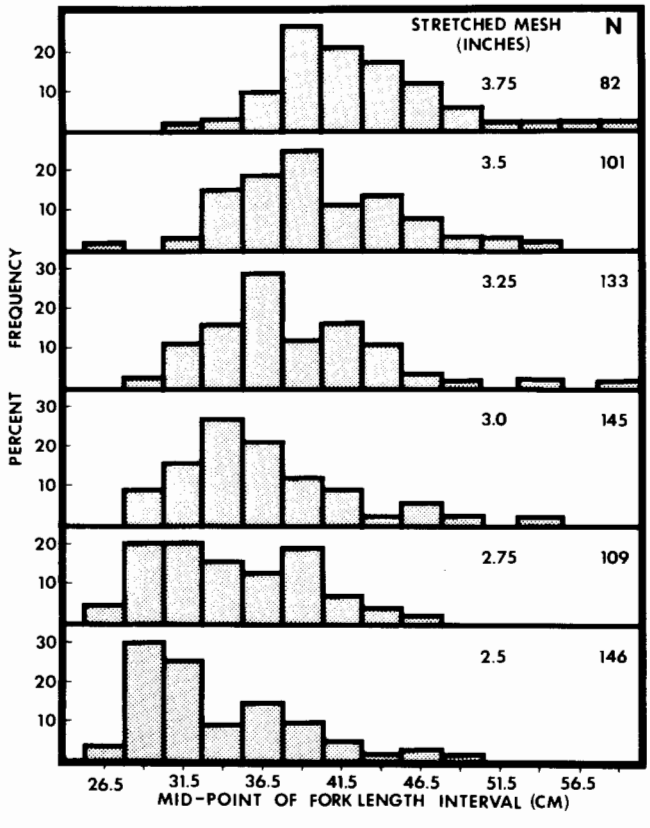

Figure 9. Length-frequency distributions of captured Spanish mackerel in relation to the mesh sizes of gill nets (Trent and Pristas 1977).

increases gradually and provides several gilling points of different sizes, and many individuals become entangled by teeth, maxillaries, or tail.

Since the beginning of the fishery, major technological changes have occurred to increase the efficiency of capturing Spanish mackerel with gill nets. In the 1800s, gasoline engines and powerful spotlights were not readily available, and fishermen were limited to using staked gill nets or inefficient techniques in setting strike nets. Webbing was made of cotton and was not as efficient as multi- or monofilament nylon for (1) getting fish to charge the net, especially during the daytime, and (2) entangling fish once they contact the net. By 1920, the fishery's boats were powered by gasoline engines and equipped with spotlights for night fishing. Techniques changed little from 1920 to the late 1950s, according to Klima's (1959) account of fishing during 1958. Strike nets made of cotton webbing were still being used, and most of the fishing still occurred at night. Stab gill nets had, however, come into use to catch mackerel in deep water. Fishing gear and methods presently used are considerably different from those of the 1950s. Larger vessels entering the fishery have power-rollers to mechanically retrieve the nets and almost all the nets are made of nylon. Much of the fishing occurs during the daytime; airplane spotter pilots locate the fish and help direct the fishing operation.

RECREATIONAL FISHERY

Based on statistics collected during the 1965 and 1970 Salt-water Angling Surveys (Deuel and Clark 1968, Deuel 1973), the most productive recreational fishing area for Spanish mackerel in the United States was along the south Atlantic coast (Cape Hatteras, North Carolina, to and including the Florida Keys) (Table 6 and Figure 10). Other areas, in decreasing order of production were: east Gulf of Mexico (Florida Keys to and including the Mississippi River delta); west Gulf of Mexico (Mississippi River delta to the Mexican border); middle Atlantic (New Jersey to Cape Hatteras). In some years, sizable catches were made as far north as Long Island, N. Y. (Berrien and Finan 1977), although catches were not reported from this area during the survey years of 1960, 1965, and 1970 (Clark 1962, Deuel and Clark 1968, Deuel 1973).

A survey of the recreational anglers and the numbers of Spanish mackerel caught in each state in the south Atlantic and Gulf of Mexico was made in 1975 by the National Marine Fisheries Service (John P. Wise, personal communication). The 1975 data showed that more Spanish mackerel were caught in the Gulf of Mexico than along the south Atlantic coast, and that Florida produced about 67% of the landings (Table 7).

Recreational anglers catch Spanish mackerel from boats while trolling or drifting, and from boats, piers, jetties, and beaches by casting, livebait fishing, jigging, and drift fishing. Lures and baits less than five inches long are usually used.

TABLE 6.

Estimated numbers and weights of Spanish mackerel* and the numbers of recreational fishermen that caught them, by area and year (Clark 1962, Deuel and Clark 1968, Deuel 1973, and John P. Wise, personal communication).

Year	Middle Atlantic	South Atlantic	East Gulf	West Gulf	Gulf	Total
			Thousands of fish			
1960	†	7,380	†	†	5,149	12,529
1965	278	7,548	1,187	521	1,708	9,534
1970	350	4,967	2,314	479	2,793	8,110
1975	†	733	†	†	3,012	3,745
			Thousands of pounds			
1960	†	24,830	†	†	11,330	36,160
1965	167	18,186	2,984	1,299	4,283	22,636
1970	946	14,623	7,200	608	7,808	23,377
1975	†	1,633	†	†	7,029	8,662
			Thousands of anglers			
1960	†	242	†	†	190	432
1965	8	202	121	46	167	377
1970	32	245	228	31	259	536
			Mean weight (pounds) per fish			
1960	†	3.4	†	†	2.2	
1965	0.6	2.4	2.5	2.5	2.5	
1970	2.7	2.9	3.1	1.3	2.5	
1975	†	2.2	†	†	2.3	

*King mackerel (*Scomberomorus cavalla*) and cero (*S. regalis*) included in the catches in 1960 and cero included in 1965 and 1970.
†Data not available or not taken such that it could be combined by the geographic areas used in the 1965 and 1970 surveys.

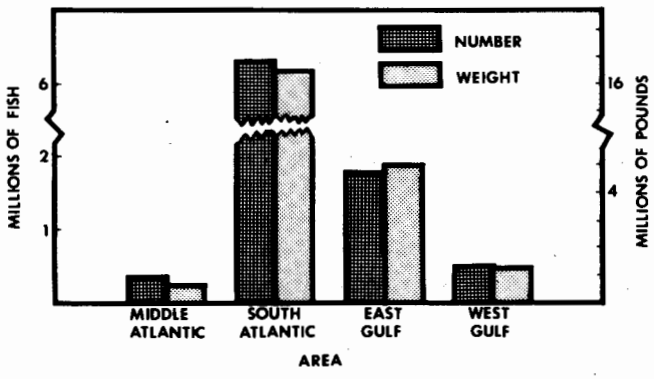

Figure 10. Estimated mean number and mean total weights of Spanish mackerel and cero caught by recreational fishermen during 1965 and 1970 by area (Deuel and Clark 1968, and Deuel 1973).

TABLE 7.

Estimated numbers and pounds of Spanish mackerel caught by recreational fishermen by state in the south Atlantic and Gulf areas in 1975 (John P. Wise, personal communication).

State	Thousands of fish	Thousands of pounds
North Carolina	377	725
South Carolina	95	176
Georgia	*	*
Florida (east)	261	732
Total	733	908
Florida (west)	2,260	5,148
Alabama	380	942
Mississippi	225	555
Louisiana	147	384
Texas	*	*
Total	3,012	7,029

*Too few to estimate.

Most Spanish mackerel are caught in the ocean; the estimated percentages of catch in the ocean, as opposed to bays and sounds, ranged from 62% in the south Atlantic to 99% in the middle Atlantic (Table 8). More Spanish mackerel were caught from small boats than all combined platforms in each area except the middle Atlantic, where most mackerel were caught from larger charter or party boats (Figure 11).

TABLE 8.

Estimated numbers of Spanish mackerel caught by recreational fishermen by fishing area, fishing platform, geographic area, and year (Deuel and Clark 1968, and Deuel 1973).

Geographic area and year	Fishing area		Fishing platform			
	Ocean	Sound	Private or rented boat	Party or charter boat	Bridge, pier, or jetty	Beach or bank
			Thousands of fish			
Middle Atlantic						
1965	278	*	29	249	*	*
1970	346	4	40	300	*	10
South Atlantic						
1965	3,796	3,752	4,880	1,149	1,424	95
1970	3,919	1,048	3,447	317	628	575
East Gulf						
1965	1,098	89	566	328	244	49
1970	1,701	613	1,188	534	488	104
West Gulf						
1965	463	58	367	73	81	*
1970	371	108	218	189	8	64

*No catch reported.

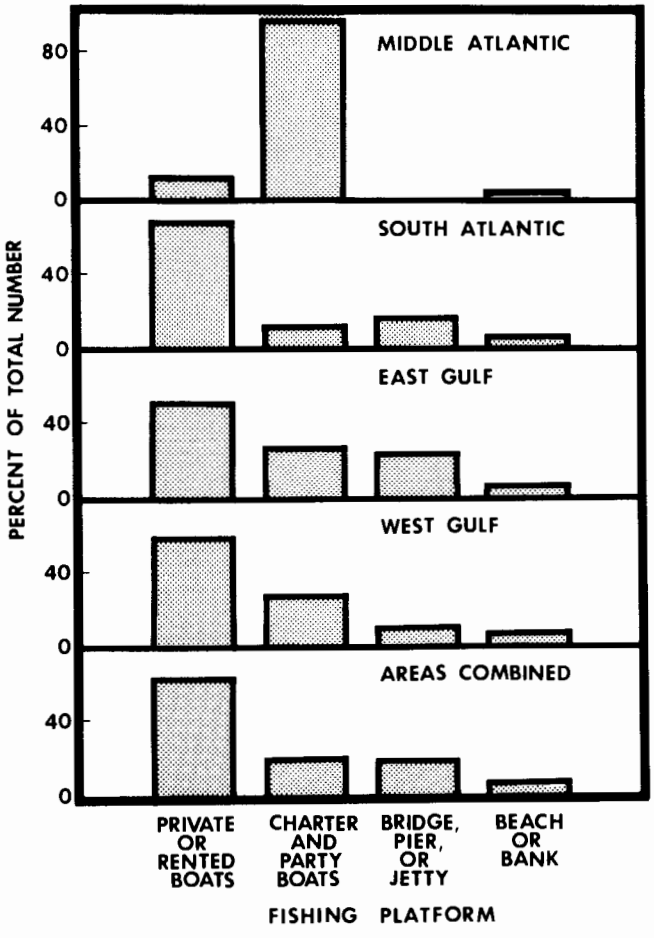

Figure 11. Percents of the total numbers of Spanish mackerel caught in each area in relation to fishing platform (Deuel and Clark 1968, and Deuel 1973).

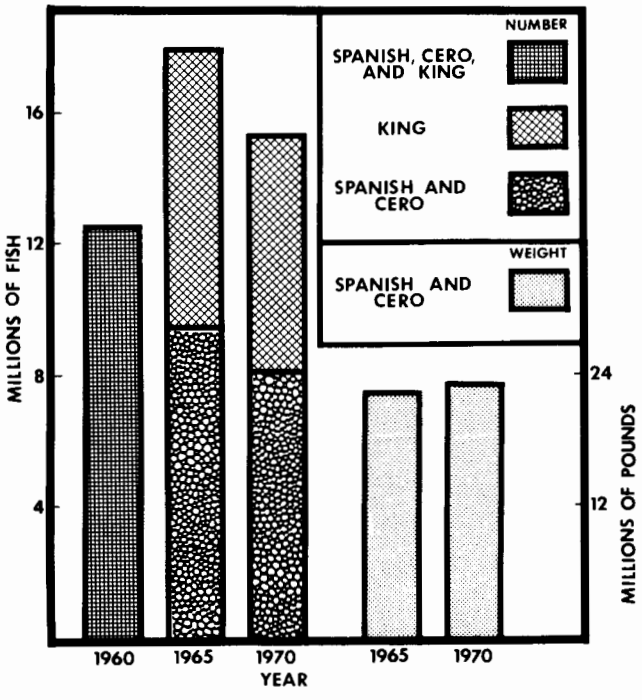

Figure 12. Estimated numbers and total weights of mackerel caught by recreational fishermen (king mackerel and cero included with Spanish mackerel during 1960 and cero only included during 1965 and 1970).

Based on the available recreational fishery statistics, significant changes in the total landings and catch per unit effort in the recreational Spanish mackerel fishery between survey periods cannot be determined with any degree of certainty. Estimated total landings of Spanish mackerel, king mackerel, and cero by recreational anglers for 1960, 1965, and 1970 are shown in Figure 12. Data on these species cannot be separated to make meaningful comparisons, because all three were reported as Spanish mackerel in 1960, and cero were reported as Spanish mackerel in 1965 and 1970. Total landings of the combined three species ranged between 12.5 and 17.9 million fish and were highest in 1965 and lowest in 1960. This difference of 5.4 million fish is small, because a conservative estimate of the probable magnitude of one standard error is between 3.7 and 5.6 million fish (Deuel 1973).

The estimated numbers of anglers that caught both or all three species of mackerels by area and year are shown in Table 6. These numbers, along with catch data, cannot be used to compute valid estimates of catch per unit effort, because the number of anglers that fished for, but did not catch, these species is unknown, as is the number of times that each angler fished for the species.

Several methods have been used to estimate values of recreational fisheries; all have their shortcomings. For this discussion, we will assume that the use of expenditure data is a reasonable valid technique for estimating the value of a recreational fishery. In 1970, the number of recreational anglers who caught Spanish mackerel in the United States was estimated at 536,000 (Deuel 1973). In the 1970 National Survey of Fishing and Hunting (U.S. Department of Interior 1972), the average annual expenditure of an angler in the south Atlantic and gulf regions was estimated at $143.00. Assuming that the percentage of the expenditure specifically for Spanish mackerel was between 20 and 60% of the annual average, the 536,000 anglers spend between $15.3 million (536,000 x $28.60) and $46.0 million (536,000 x $85.80) fishing for Spanish mackerel.

DISCUSSION

This paper contains a summary of what is known about the landings of Spanish mackerel in the United States and how the fish were captured. With these data we can tell little, however, about the well being of Spanish mackerel stocks. The greatest single-year increase in commercial landings – over 6 million pounds – occurred between 1975 and 1976 (Figure 7). Does this mean that the maximum sustained yield has been surpassed? Did the large price increase from $0.13 per pound in 1972 to $0.18 in 1976 make the taking of Spanish mackerel so profitable that the resource will be over-harvested in the near future? Or are

the stocks fluctuating within normal limits and recent harvests merely represent catches during a peak abundance period? These questions cannot be answered with the presently available information. The potential for exhausting the Spanish mackerel resource was explored by Shaw and Warner (in press) by reviewing case histories of several pelagic fisheries. These authors examined the expansion of the Spanish mackerel fishery and the expansions and declines of the Pacific mackerel *Scomber japonicus*, Pacific sardine *Sardinops sagax*, and Atlantic menhaden *Brevoortia tyrannus*, fisheries. Importantly, the population declines could not be predicted based on the data that were available at the time.

We are not presently collecting the types of data that are required to estimate maximum allowable harvest (MAH). To estimate MAH we must as a minimum, (1) have accurate effort, catch, and catch-per-unit-effort (CPUE) estimates, and data on the size and age composition of the catch, or (2) use some other type of data to estimate the size or relative size of the stocks from year to year.

The method presently used to obtain catch and effort statistics on commercial fisheries only provides total landings by type of gear and total numbers of units of each gear within geographic areas. What is lacking, in regard to estimating CPUE, is the number of "standard units of fishing effort" exerted to catch a particular species of fish. The problem of effort standardization applies to the gathering of recreational effort statistics also, but with the additional problem of having to estimate total landings.

A standard unit of fishing effort can be defined as an amount of fishing, with a specific type of gear, that will capture an unknown but constant proportion of fish population per unit time; this amount when quantified is called the "fishing power" of the gear. A single standard unit of effort cannot be defined for the Spanish mackerel fishery. Further, it is extremely difficult to define a standard unit of effort for any of the numerous types (gill nets, haul seines, small-boat trolling, pier fishing, etc.) of fishing that occur in this fishery. Variations in the strike gill net fishery illustrate the difficulties in defining a standard unit of effort. In theory, fishing power is constant in a standard unit of fishing effort, and in practice the variability in fishing power should remain low within a gear type. Within the strike gill net fishery, however, the fishing power of a boat will vary by: size of boat; equipment and number of people aboard; length, depth, and mesh size of nets; degree of concentration on capturing a single species; hours fished per day; whether a spotter plane is used; restrictions on pounds landed per day; and other factors. From a sampling standpoint the solution to estimating total fishing effort is extremely costly. Thus tremendous amounts of resources must be spent to design and conduct surveys to obtain estimates, or valid estimates of total effort will not become available. These effort estimates, in conjunction with total catch data, are required to determine if overfishing is occurring. The availability of necessary funds in the near future for significant improvement in estimating total effort is difficult to foresee.

Methods other than the collection of catch and effort statistics have been proposed to monitor and estimate sizes of fish stocks, e.g., the use of egg and larval data from plankton collections (Houde 1977) and the use of aerial and satellite remote sensing (Kemmerer, Benigno, Reese, and Minkler 1974). These techniques are not, however, sufficiently advanced at this time for determining the status of Spanish mackerel stocks.

Based on the present economic constraints, the best short-term solution to the assessment of Spanish mackerel stocks is to continue monitoring commercial landing data and begin sampling the size and age composition of the stocks. If additional funds become available they should be used to (1) improve the methods of total catch and effort estimation in the recreational fishery, and (2) develop methods to estimate total effort in the commercial fishery. These data, if obtained annually, would greatly improve our capability of determining, on a timely basis, if overfishing is occurring.

Accurate catch and effort statistics, and size and age composition of the catch, represent only a part of the required data to manage the Spanish mackerel fisheries for optimum yields. Additional factors requiring data or definition include: sociological profiles of the fishermen (Austin et al. 1978, Ditton 1977); economics of the fishery and systems of processing, distribution, and marketing (Prochaska and Cato 1977); and interactions among the harvesting sectors (Austin et al. 1978).

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APPENDIX TABLE 1.

Spanish and king mackerel landings by area in the United States, 1968–1976

Year	Middle Atlantic		Chesapeake		South Atlantic		Gulf		Total United States	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(Thousands of pounds and thousands of dollars)									
	Spanish mackerel									
1968	*	*	60	10	4,484	391	7,232	812	11,776	1,213
1969	*	*	124	18	2,452	266	8,342	759	10,918	1,243
1970	*	*	201	31	3,639	468	8,298	972	12,138	1,471
1971	*	*	52	9	2,381	323	7,658	858	10,391	1,190
1972	*	*	23	4	3,475	441	7,222	893	10,720	1,338
1973	*	*	50	9	3,276	548	6,457	1,027	9,783	1,584
1974	2	*	24	4	2,422	468	8,554	1,480	11,002	1,952
1975	*	*	62	12	5,210	911	6,138	1,040	11,410	1,963
1976	*	*	80	13	9,627	1,766	8,342	1,466	18,049	3,245
	King mackerel**									
1968	*	*	3	1	2,594	505	3,604	464	6,201	970
1969	*	*	2	*	2,961	603	3,242	415	6,205	1,018
1970	*	*	5	1	4,351	1,018	2,372	320	6,728	1,339
1971	*	*	7	1	2,923	823	2,738	472	5,668	1,296
1972	*	*	2	*	3,499	1,054	1,378	255	4,879	1,309
1973	*	*	7	1	3,749	1,549	2,217	597	5,974	2,147
1974	*	*	15	4	4,317	1,706	6,133	1,594	10,465	3,304
1975	*	*	13	4	3,806	1,780	2,622	640	6,441	2,424
1976	*	*	9	4	4,989	2,654	2,802	891	7,800	3,549

*Less than 500 pounds or $500.

**Includes the catch of cero *Scomberomorus regalis*

NOTE: These tabulations do not include a negligible production in New England.

APPENDIX TABLE 2.

Spanish and king mackerel landings in the middle Atlantic and Chesapeake states, 1968–1976

Year	New York		New Jersey		Total		Maryland		Virginia		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(Thousands of pounds and thousands of dollars)											
	Spanish mackerel											
1968	*	*	*	*	*	*	2	*	58	10	60	10
1969	**	**	**	**	**	**	1	*	123	18	124	18
1970	*	*	*	*	*	*	1	*	200	31	201	31
1971	*	*	*	*	*	*	1	*	51	9	52	9
1972	*	*	*	*	*	*	*	*	23	4	23	4
1973	*	*	*	*	*	*	*	*	50	9	50	9
1974	*	*	*	*	*	*	*	*	24	4	24	4
1975	*	*	*	*	*	*	*	*	62	12	62	12
1976	*	*	*	*	*	*	*	*	80	13	80	13
	King mackerel											
1968	*	*	*	*	*	*	*	*	3	1	3	1
1969	*	*	*	*	*	*	*	*	2	*	2	*
1970	*	*	*	*	*	*	*	*	5	1	5	1
1971	*	*	*	*	*	*	*	*	7	1	7	1
1972	*	*	*	*	*	*	*	*	2	*	2	*
1973	*	*	1	*	1	1	*	*	7	1	7	1
1974	*	*	*	*	*	*	*	*	15	4	15	4

*Less than 500 pounds or $500.
**Data not available.
NOTE: Production is limited to New York and New Jersey in the middle Atlantic states.

APPENDIX TABLE 3.

Spanish and king mackerel landings in the south Atlantic states, 1968–1976

Year	North Carolina		South Carolina		Georgia		Florida East Coast		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(Thousands of pounds and thousands of dollars)									
	Spanish mackerel									
1968	69	8	8	1	1	*	4,406	382	4,484	391
1969	89	12	4	1	*	*	2,359	253	2,452	266
1970	63	9	2	*	*	*	3,574	459	3,639	468
1971	95	14	4	1	*	*	2,582	308	2,681	323
1972	96	13	5	1	5	1	3,369	426	3,475	441
1973	64	9	4	*	5	1	3,203	538	3,276	548
1974	73	9	2	*	1	*	2,346	459	2,422	468
1975	49	7	10	2	6	1	5,145	901	5,210	911
1976	31	5	4	1	3	1	9,589	1,777	9,627	1,784
	King mackerel									
1968	8	2	*	*	*	*	2,586	503	2,594	505
1969	16	4	2	*	*	*	2,943	599	2,961	603
1970	12	3	*	*	1	*	4,338	1,015	4,351	1,018
1971	9	2	6	1	1	*	2,907	820	2,923	823
1972	9	3	1	*	*	*	3,489	1,051	3,499	1,054
1973	26	7	11	5	*	*	3,712	1,537	3,749	1,549
1974	40	24	4	2	6	2	4,267	1,678	4,317	1,706
1975	100	60	8	4	1	1	3,697	1,715	3,806	1,780
1976	156	109	8	5	4	2	4,821	2,538	4,989	2,654

*Less than 500 pounds or $500.

APPENDIX TABLE 4.

Spanish and king mackerel landings in the gulf states, 1968–1976

Year	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	(Thousands of pounds and thousands of dollars)											
	Spanish mackerel											
1968	7,066	797	39	3	114	11	10	1	3	*	7,232	812
1969	8,175	946	85	6	12	1	70	6	*	*	8,342	959
1970	8,100	939	126	26	43	5	29	2	*	*	8,298	972
1971	7,383	830	56	5	179	20	40	3	*	*	7,658	858
1972	6,532	816	91	9	485	57	114	11	*	*	7,222	893
1973	6,194	999	76	6	98	14	89	8	*	*	6,457	1,027
1974	8,267	1,444	54	6	41	6	192	24	*	*	8,554	1,480
1975	5,621	961	92	11	225	39	200	29	*	*	6,138	1,040
1976	7,783	1,360	45	5	379	82	135	19	*	*	8,342	1,466
	King mackerel											
1968	3,604	464	*	*	*	*	*	*	*	*	3,604	464
1969	3,242	415	*	*	*	*	*	*	*	*	3,242	415
1970	2,372	320	*	*	*	*	*	*	*	*	2,372	320
1971	2,738	472	*	*	*	*	*	*	*	*	2,738	472
1972	1,378	255	*	*	*	*	*	*	*	*	1,378	255
1973	2,217	597	*	*	*	*	*	*	*	*	2,217	597
1974	6,133	1,594	*	*	*	*	*	*	*	*	6,133	1,594
1975	2,622	640	*	*	*	*	*	*	*	*	2,622	640
1976	2,802	891	*	*	*	*	*	*	*	*	2,802	891

*Less than 500 pounds or $500.